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Examining Traumatic Bone Fracture Healing Versus Surgical Osteotomies in Canines and Resulting Rates of Infection

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Honors Research Project

Examining Traumatic Bone Fracture Healing Versus Surgical Osteotomies in Canines and Resulting Rates of Infection

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Abstract

The development of osteomyelitis after surgical osteotomies and fracture repair in canines can propose serious health risks, ultimately leading to additional intervention from veterinarians that can become costly for pet owners and effect prognosis for the patient. Preventive measures are currently implemented during surgery and postoperatively. However, infection rates still range from 3.0% to 7.9% (Clark et al., 2018). By examining traumatic bone fracture healing versus surgical osteotomies in canines through the collection of both clinical and radiographic medical records, our primary objective was to further understand the physiological mechanism by which osteomyelitis develops. Limitations related to the collection of cases and medical records that met inclusion criteria resulted in an uneven sample size between surgical osteotomy cases (n=42) and fracture cases (n=8). Due in part to the limited availability of fracture cases, we did not observe a higher incidence of bone infection in canines following traumatic bone fracture versus those who underwent surgical osteotomy. There were slightly higher reports of complications in surgical osteotomy versus fracture cases characterized by abnormal localized swelling, surgical site drainage, and abnormal localized swelling on postoperative radiographs. No differences in the presence or absence of fever or abnormal periosteal reaction were observed. Further data collection using a larger and equal number of surgical osteotomy and fracture cases may aid in detecting significant differences between groups.

Introduction

The development of osteomyelitis following traumatic lower-limb fracture repair or surgical osteotomy, specifically tibial plateau leveling osteotomy (TPLO), can have detrimental effects on canines. TPLO is performed in animals with cranial cruciate ligament rupture and is one of the most common procedures involving osteotomy in veterinary medicine. The osteotomy functions to rotate the tibial plateau, decreasing its angle to stabilize the stifle joint. Stabilization occurs by eliminating cranial translational forces of the tibia during weight-bearing, which the cranial cruciate ligament would normally combat in the healthy patient. Development of osteomyelitis following TPLO or fracture repair can increase the duration of the healing process, increase patient morbidity, cause chronic lameness, and decrease the success rate of the procedure. Infection can lead to severe pain, sepsis, osteonecrosis, or increased risk of mortality. Understanding the pathogenesis of osteomyelitis is essential when comparing its occurrence in bone fractures versus surgical osteotomies. Osteomyelitis, or inflammation of bone marrow secondary to an infection, can develop via three distinct pathways: direct inoculation of bacteria to the site, the spread of bacteria via blood, or the spread of bacteria from a nearby infection into bone tissue (Lee et al., 2016). Differentiating such pathways can provide insight into possible areas of prevention and clinical imaging of affected skeletal elements to establish diagnoses, guide early management, and reduce long-term complications. Although various preventative measures are already implemented by veterinary surgeons in an attempt to lower rates of osteomyelitis, postoperative infection rates still range from 3.0% to 7.9% (Clark et al., 2018).

Such incidence is a concern and provides a promising area of future research. If an infection does develop, treatment options can be very expensive for pet-owners and require prolonged administration of antibiotics and/or additional surgeries to resolve it. Implementing additional preventative measures may aid in making pet care more affordable for pet owners and decrease long-term exposure to antibiotics. Exposure to antibiotics may be harmful to the gastrointestinal tract of canines and promote the development of antibiotic resistance (Barnhart et al., 2019; Downes et al., 2015). By examining traumatic bone fracture healing, surgical osteotomies, and associated medical records, we hope to further understand the physiological mechanism by which osteomyelitis develops. This may then be used in the future to formulate preventative measures that could be beneficial in the clinical setting. The goal of this study is to address the following research questions: 1) what further information regarding the physiological mechanism of osteomyelitis can be gleaned through the evaluation of radiographs?, and 2) is there a significant difference between osteomyelitis rates and the severity of infection in canines healing from traumatic bone fracture versus those who are healing from surgical osteotomy? In the future, we aim to correlate imaging findings associated with osteomyelitis with the underlying pathological processes. Our primary hypothesis is that there will be a higher incidence and increased severity of bone infection in canines following traumatic bone fracture versus those who have undergone TPLO.

Materials and Methods

Data Collection

Radiographs and corresponding clinical records were obtained and analyzed from patients at a specialty and emergency veterinary hospital (MedVet Akron, Akron, Ohio). Canines that underwent TPLO or surgical stabilization for traumatic fracture of the tibia or femur were included. Inclusion criteria for these cases consisted of patient medical records and radiographs from large breed male and female canines within an 18-50 kg weight range. Data was collected via ezyVet (Newmarket, Auckland), a cloud-based Veterinary Practice Management Software. For an example of the ezyVet interface, see **Figure 1**. Images of radiographs were obtained through the use of a Vet-X-ray (APR-VET) system. Due to distinct bone growth and development characteristics of canines, the cases were further limited to adults ranging in age from 1-9 years old (Bellows et al., 2015). Analyzing datasets from animals with mature bone, who are not yet geriatric, functions in establishing consistency in the duration of the bone healing and remodeling processes. Bone maturity was concluded by the presence of closed physes. Patient signalment was recorded as well as the dates of surgery and each follow-up appointment. Follow-up evaluation for both fracture and TPLO patients were recommended for 2-3 weeks and 6-8 weeks post-operation. The number of weeks between surgery and each follow up appointment was calculated. Data relating to the operation were recorded including surgery duration, anesthesia duration, and which limb was effected.

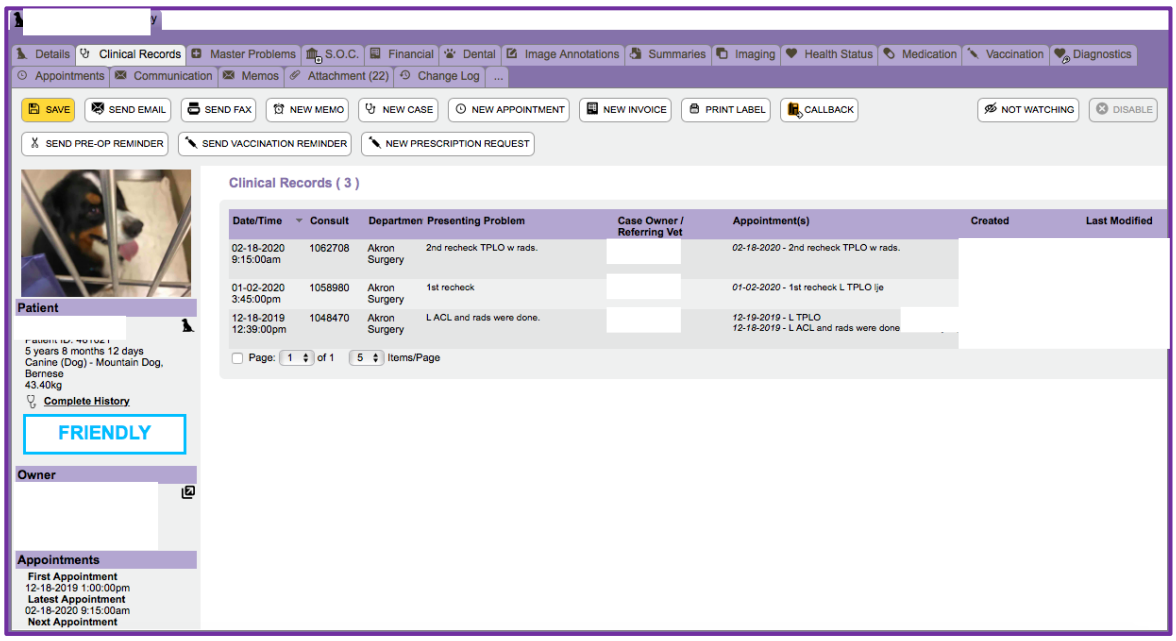

Figure 1. Displays a view of the ezyVet interface where patient signalment, clinical, and radiographic data were collected.

Description of Fracture Parameters

Grade 1 closed fractures of the tibia and femur were included. According to the Tscherne classification system, Grade 1 closed fractures include any fracture with mild to moderate energy and only superficial contusions (Ibrahim et al., 2017). Open fractures were not included. To increase consistency between groups and limit variables and confounding factors, fractures were included only if bone plate and screw constructs were used, as this is what is used for TPLO stabilization. See **Figure 2** for an example of plate and screw fixation for fracture repair after a comminuted tibial fracture. Fractures were recorded as low energy or high energy dependent on the trauma causing the fracture. For example, falling from a low height was characterized as low energy. Vehicular trauma was considered high energy. The location of the fracture of

the affected bone, type of fracture, and impact type was documented. Only fractures of the diaphysis were included.

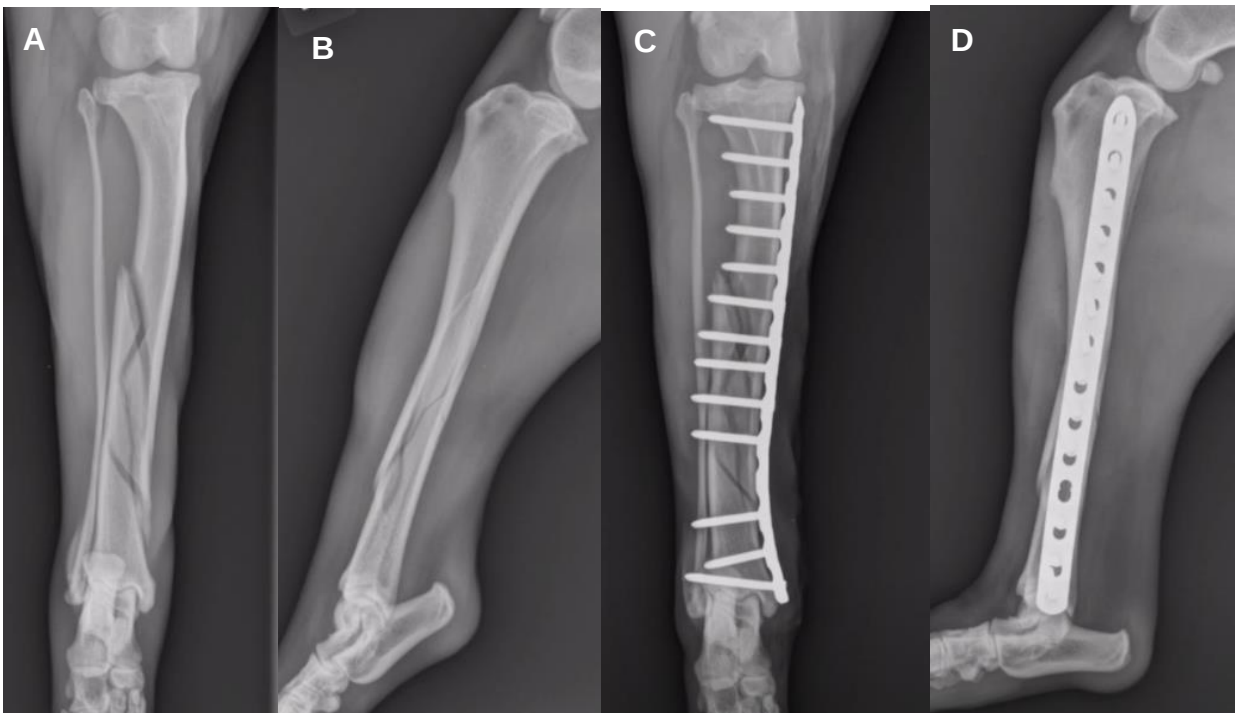

Figure 2. Radiographs of a 31.0 kg, 3.2-year-old neutered male Labrador retriever. A mildly cominuted fracture with a large spiral component of the right tibia was sustained. On the right is an (A) anteroposterior and (B) lateral preoperative view of the fracture before intervention. An (C) anteroposterior and (B) lateral view of the fracture after plate and screw fixation follows.

Description of Clinical Evidence for Infection

Clinical signs of infection were recorded and defined as: surgical site drainage, incisional dehiscence, abnormal localized swelling, or fever (greater than 103 degrees Fahrenheit). The character of surgical site drainage was documented such as purulence, cloudy appearance, or yellowish tint, all of which may be indicative of

infection (Eugster et al., 2004; Miller 2011). Although follow up laboratory testing was limited among patients, testing that provided additional evidence of infection such as bacterial cultures were also recorded.

Description of Radiologic Evidence for Infection

Radiographs were accessed from medical record software (ezyVet). Radiographic data were then analyzed using Radiology Information System (RIS) to assess the following parameters among individuals from each group: the amount of postoperative bony callus formation, localized soft tissue swelling, and abnormal periosteal reaction. The severity of postoperative bony callus was recorded as absent, present and excessive amount, present and normal amount, and present but lesser than expected amount. The presence or absence of localized soft tissue swelling and abnormal periosteal reaction was also documented. **Figure 3** displays normal postoperative TPLO healing, whereas, **Figure 4** shows abnormal healing. Each fracture case was analyzed in the same way.

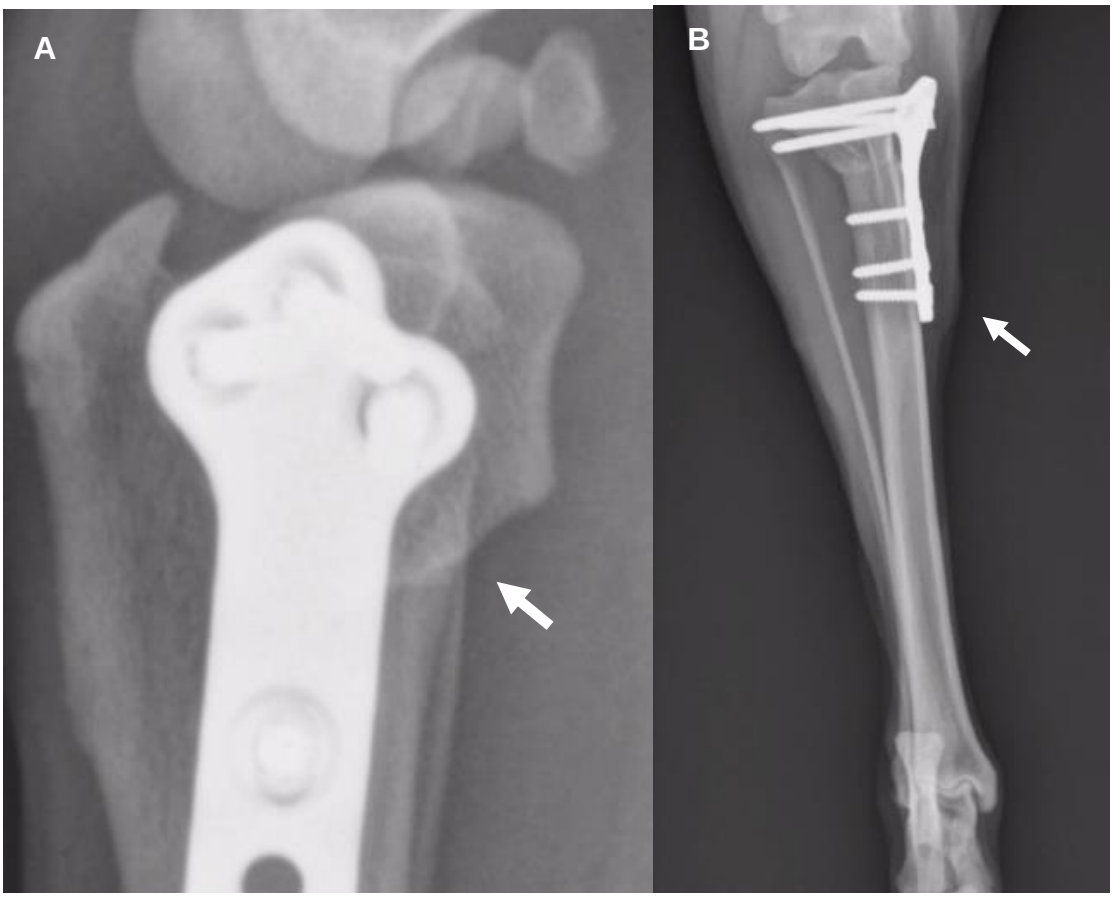

Figure 3. Normal healing from TPLO (7.7 weeks postoperative). (A) Lateral view postoperative of a healed TPLO without signs of an abnormal periosteal reaction and normal bony callus formation, indicated by the white arrow. (B) Anteroposterior view of a healed TPLO with no abnormal soft tissue swelling, indicated by the white arrow.

Figure 4. Abnormal healing after TPLO (7 weeks postoperative). (A) Abnormal periosteal reaction and increased irregular boney callus (white arrow). (B) presence of soft tissue swelling and increased radiopacity (white arrow). These could be indicative of osteomyelitis or instability.

Statistical Analyses

To evaluate the infection rates in fracture patients versus those undergoing TPLOs, multiple *t*-test analyses were performed using Microsoft Excel 16.30 (19101301). Descriptive statistics were completed to determine the normality of residuals, homogeneity of variance, and if the data represent a random and sizeable sample. The data was continuous, thus, fitting the scale of measurement assumption.

The distribution was collected randomly from the entire population. However, the sample size was inadequate for fracture repair patients as it only consisted of eight cases. Due to the unequal distribution of TPLOs and fractures, data failed to pass the homogeneity of variance assumption. Lastly, the data distribution was skewed and asymmetrical, thus, it also failed the normality test (Maverick, 2019). Considering the failure of 3 out of the 5 assumptions, results cannot be interpreted as accurate. If a larger and equal sample size between groups had been obtained, analyses would have been re-run and log transformed.

Results

Data Collection and Sample Size

The sample size for TPLO patients consisted of 42 medical records that were collected between September 2019 and December 2019. Collecting fracture medical records proved to be much more challenging, therefore we expanded the timeframe of data collection from September 2019 through December 2019 to January 2016 through December 2019. A total of 8 fracture medical records were collected, with 7 high energy and 1 low energy. The average number of weeks between TPLO or fracture repair procedures to the first recheck appointment was 2.9 weeks and the average time from either procedure to the second recheck was 9.2 weeks.

Dehiscence

Dehiscence at either recheck appointment for cases are summarized in **Figure 7**. 97.6% of TPLOs did not show clinical signs of dehiscence during the first recheck (2.4% did show signs of dehiscence). There were no signs of dehiscence in the fracture group

at either recheck evaluation. According to the p-values of the first recheck (p = 0.0460) and second recheck (p = 0.00320), there is a significant difference between clinical signs of dehiscence between TPLO versus fracture repair patients, with TPLO patients showing increased dehiscence (**Table 1**).

Abnormal Localized Swelling

The presence or absence of abnormal localized swelling during the first and second follow up evaluation for TPLO and fracture repair is displayed in **Figure 8**. During the first follow up appointment, approximately 88.1 % of TPLO patients did not exhibit clinical signs of abnormal swelling (12.0% did). Regarding the second recheck appointment, 87.8 % of TPLO patients did not exhibit signs of abnormal swelling (12.2% did). No fracture patients showed abnormal localized swelling during either recheck evaluation. The p-values of the first recheck (p = 0.1887) and the second recheck (p = 0.3984), were not significant between the treatment groups (**Table 2**).

Clinical Signs of Surgical Site Drainage

Data displayed in **Figure 10** shows the percentages of patients with and without surgical site drainage during either recheck evaluation for TPLO and fracture repair patients. No TPLO patients exhibited clinical signs of surgical site drainage during the first recheck. Approximately 97.6 % of patients did not have a record of surgical site drainage during the second recheck (2.44 % did). No fracture patients had signs of surgical site drainage. There was a significant difference between calculated p-values of the first recheck (p = 0.003192) and second recheck (p = 0.01547) (**Table 3**).

Mean Anesthesia Duration

The mean anesthesia duration for TPLO procedures was 116.79 minutes, whereas, the mean anesthesia duration for fracture repairs was 200.00 minutes (**Figure 11**). Thus, there was a difference of 83.21 minutes between the average fracture repair versus TPLO procedure. Since the p-value was 2.732, results are not significant (**Table 4**).

Abnormal Localized Swelling on Radiographs

The data represented in **Figure 14** displays differences in the incidence of abnormal localized swelling in TPLO versus fracture repair on recheck radiographs. Approximately 78.1 % of TPLO patients did not show signs of localized swelling on recheck radiographs (22% did). Approximately 87.5 % of fracture repair patients did not show abnormal localized swelling on recheck radiographs (12.5% did). Since the calculated p-value is 0.5743, there was no significant difference between groups.

Discussion

The development of osteomyelitis after TPLO or fracture repair has detrimental effects on the patient. It is essential to understand the physiologic mechanism by which osteomyelitis develops. If this is understood more thoroughly, preventative measures may be developed to decrease postoperative TPLO infection rates which currently are 3.0 - 7.9% (Clark et al., 2018). There are various mechanisms by which osteomyelitis can develop. Such mechanisms include the direct inoculation of bacteria, the spread of bacteria via blood, or the spread of bacteria from a nearby infection into bone tissue. Direct inoculation refers to the placement of bacteria directly into bone from surgical

intervention or penetrating trauma, whereas, hematogenous and continuous spread occur endogenously and are less likely to be a direct result of surgical contamination (Lee et al., 2016). Though many different microorganisms cause infection, understanding the various methods by which it spreads could reveal further insight into areas of prevention. The objective of the study was to examine traumatic bone fracture healing versus surgical osteotomy in canines and the resulting rates of infections through the collection and analyses of both clinical and radiographic data.

Though the collection of clinical and radiographic data was conducted, there were very few patients that fit the inclusion criteria for the fracture group. Consequently, the greatest limitation of the study was an inadequate sample size. To account for this limitation, inclusion criteria such as weight, age, and sex were expanded. After broadening inclusion parameters, the number of total fracture patients was still less than half of the originally proposed sample size. As only eight patients fit within the fracture inclusion criteria, the sample population was not reflective of the total population statistically.

Other studies suggest that broadening inclusion parameters could have negatively influenced the significance of the data as well. The difference between the heaviest and lightest canine weights included in the distribution was 29.0 kg. A comparative study on the postoperative infection rates performed by veterinarians explained that animals with dissimilarities in weight may result in different risks of infection. The study reported that the higher the weight of the animal, the greater the chances for developing an infection. Potential explanations for such a correlation could arise from a difference in canine health and/or behavior. Greater levels of stress due to

increased body weight may, in turn, increase irritation and subsequent inflammation near the affected site (Eugster et al., 2004). Another probable reason for the increase in the risk of infection for larger canines may be due to the increased duration of surgery and anesthesia commonly experienced by larger breed canines. Numerous previous studies support that there is a direct correlation between the length of surgery and anesthesia duration and the weight of an animal (Clark et al., 2018; Downes et al., 2015; Eugster et al., 2004). Due to the relationship between weight and chances of developing a postoperative infection, it may be beneficial to collect data within a narrower weight range than 29.0 kg to accommodate these potential inconsistencies.

In addition to decreasing the weight range, altering the age range of inclusion may further add to the significance of the results. Multiple immune-related studies suggest that the differences in bone healing and remodeling may be due to differences in homeostatic control and regulation. Canines are considered seniors when they reach 6 years old. A decline in homeostatic maintenance due to aging may serve as a barrier in an animal's ability to heal from a surgical procedure, and fight postoperative infection (Bellows et al., 2015; Connors 2019). In contrast, younger animals, with better homeostatic regulation may be more equipped to heal from surgery and fight infections. Furthermore, an additional study on the development of infection and administration of antimicrobials, suggests that the relationship between an increased risk of infection with age may also be due to differences in vascular tissue heath (Clark et al., 2018). A decrease in blood perfusion and subsequent oxygen supply to tissues may negatively impact the healing process. Inadequate oxygen supply hinders the production of proteins and fibroblasts, overall impeding recovery (Winkler, 2019). In terms of the

immune system and fighting infection, an increase in age can also hinder immunoregulation. A study on T-cell formation and regulation suggested that the decline in homeostatic control associated with age leads to immunosenescence (Connors et al., 2019). Therefore, to prevent a wide age range of patient inclusion from hindering significance, it may be beneficial to narrow the ages of inclusion even further than 1 – 8 years old.

To assess the presence and degree of infection, clinical parameters were established. Since wound separation can be indicative of abnormal healing and/or infection, this was examined (Eugster et al., 2004). Although a very small percentage of TPLO and fracture repair patients showed signs of dehiscence in their clinical examination, it still serves as a valuable tool in identifying a potential infection. Because dehiscence is rare in clean surgical incisions, a large sample size would be helpful to increase strength of any conclusions made regarding this variable.

Fever was also assessed as a clinical sign of infection. Although fever is not diagnostic for infection alone, it can operate as a potential indicator. A recent study on the pathophysiology and consequences of fever development, explains that a fever arises when foreign pathogens interact with immune cells (Carraretti et al., 2016). A rise in body temperature may provide the host with an advantage against an invasion of microorganisms. An elevated body temperature may be an advantage acquired through evolution to function in destroying foreign pathogens that are not capable of surviving higher temperatures (Akilzhanova et al., 2016; Carraretti et al., 2016). Due to the physiological immune response and elevation of temperature upon infection, fever was

assessed as a clinical sign of infection. However, due to a limited sample size, no relevant data was collected for this variable and it could not be assessed.

In addition to dehiscence and fever, abnormal localized swelling was also examined. Swelling or inflammation can result from various factors. Although certain factors may not be specifically indicative of infection, it could support it. Immunoregulation to maintain homeostasis includes the recruitment of neutrophils, mast cells, and macrophages upon detection of bacterial infections. Neutrophils, macrophages, and mast cells synthesize proinflammatory cytokines that work at the site of infection. B and T lymphocytes also assist in the detection and destruction of pathogens (An and Zhang, 2009; Connors et al., 2019; Eugster et al, 2004). Although, the results of this study were not statistically significant, swelling should continue to be used as one indicator of possible infection in future studies.

Surgical site drainage was also assessed. Surgical site drainage was more common in TPLO patients than fracture patients. According to a previous study on wound healing and drainage, damage to cells can alter blood flow at the site of injury by increasing vascular perfusion. For three days following cellular trauma, increased blood flow directed to the site of injury results in water, plasma, protein, electrolyte, and antibody leakage. Fluid buildup at the site of injury combined with an incompletely sealed surgical incision may subsequently result in surgical site drainage (Fay, 1987). Although, surgical site drainage may not necessarily indicate infection as the only cause. To determine whether or not drainage results from infection, color classification may be useful. According to a study in which surgical site discharge was also examined, only purulent, or pus-filled yellowish discharge was termed as a clear indication of

wound infection (Eugster et al., 2004). To abide by clinical identification of infection, consistent with previous studies, the assessment of surgical site drainage should be implemented as an indicator in future work.

In addition to observed clinical signs of infection, the mean surgery and anesthesia duration were recorded. Previous studies have linked prolonged surgery and anesthesia duration to greater risks for osteomyelitis. Correlations may be due to increased time for bacteria to enter the site of surgery (Clark et al., 2018; Downes et al., 2015; Eugster et al., 2004). Due to an inadequacy in the number of recorded surgery durations for fracture repairs, this was not evaluated as a factor to increase the infection rate. However, the mean anesthesia duration for TPLO procedures (116.79 minutes) was less than the average anesthesia duration for fractures (200.00 minutes) by 88.21 minutes. Therefore, increased anesthesia time was not associated with increased infection in this study. With a larger sample size, perhaps this may be more robust.

Signs of infection were further examined through the collection of radiographs. Due to the placement and relatively large size of the plates and screws, limited bone was visible. Soft tissue swelling on radiographs was examined since the immune system responds to bacteria with subsequent inflammation (Lee et al., 2016). There was no statistical difference in infection rates between TPLO and fracture patients evident on radiographic examination.

Furthermore, abnormal periosteal reaction was recorded as either present or absent. In a recent study on osteomyelitis and its pathogenesis, a periosteal reaction can result from the spreading of exudate and inflammatory cells through the medullary cavity and subperiosteal surface of bone. Such an accumulation of pus can initiate the

development of a subperiosteal abscess and subsequent periosteal elevation (Lee et al., 2016). In an attempt to abide by previous studies on radiographic evidence for infection, periosteal reaction was also inspected. Though data was collected, the sample size was too small to perform accurate statistical analysis.

One area that could improve the detection of bone healing abnormalities could include altering the modality by which bone was imaged. Although radiographs are considerably less expensive, their imaging is relatively low resolution and is two dimensional compared to other types of imaging, such as Computed Tomography (CT), and the sensitivity is poor for diagnosing osteomyelitis (Barber and Webb, 2016; Bouaziz et al., 2012). Additionally, due to low imaging resolution, osteomyelitis manifestation takes considerably longer to be detected via plain radiography. Other studies report that osteomyelitis may not be discernable until approximately 2 weeks following its manifestation via radiographic evaluation (Aliabadi and Nikpoor, 1994; Barber and Webb, 2016; Lipsky, 1997). Not only may it take a prolonged period of time to view on plain radiography, but the infection must be relatively aggressive. A similar study suggests the extent of aggression by reporting that bone reabsorption needs to reach 40 - 70% for osteomyelitis to be visualized on radiographs (Lipsky, 1997). Though radiographs help identify abnormalities during the bone healing process, they are not very sensitive in confirming osteomyelitis. Due to cost and need for sedation, it may not be reasonable to collect CT scans instead of radiographs to conduct a similar study, yet it is important to understand alternative methods that could provide more quantitative and significant results for future studies

In addition to narrowing the inclusion criteria and altering the imaging modality to further confirm osteomyelitis, other factors that could have aided in providing more descriptive and accurate results need to be considered. A study conducted by veterinarians on postoperative infections in canines and felines accounted for a variable that had not yet been studied, the number of individuals within the room during surgery. According to their reports, the chances of developing an infection were 1.3 times greater per person within the surgical room during the procedure (Eugster et al., 2004). Therefore, inclusion of this variable may be valuable to assess in future work.

Conclusion

Through the examination of traumatic bone fracture healing versus surgical osteotomies in canines through the collection and evaluation of both clinical and radiographic medical records, we attempted to further understand the physiological mechanism by which osteomyelitis develops. Due to a limited sample size and therefore low power, we were not able to perform adequate statistical analyses in this case. However, future studies utilizing a larger and equal number of TPLO and fracture cases may help to identify additional interventions, decrease the healing duration for canines, and decrease the costs for pet owners.

Acknowledgements

I would like to personally thank MedVet, especially Drs. Davis, Vogt, and McBrien. Additionally, I would like to thank Dr. Andronowski for her supervision and investment in the project. I also acknowledge Zach Paris who assisted with data collection of medical records and Dr. Bagatto for his review.

Appendix

Weight Distribution

Figure 5 displays the minimum and maximum weight ranges among patients for TPLO and fracture repairs. The heaviest weight included in the patient distribution was 49.0 kg and the lightest was 20.0 kg. The difference between the heaviest and lightest canines included was 29.0 kg.

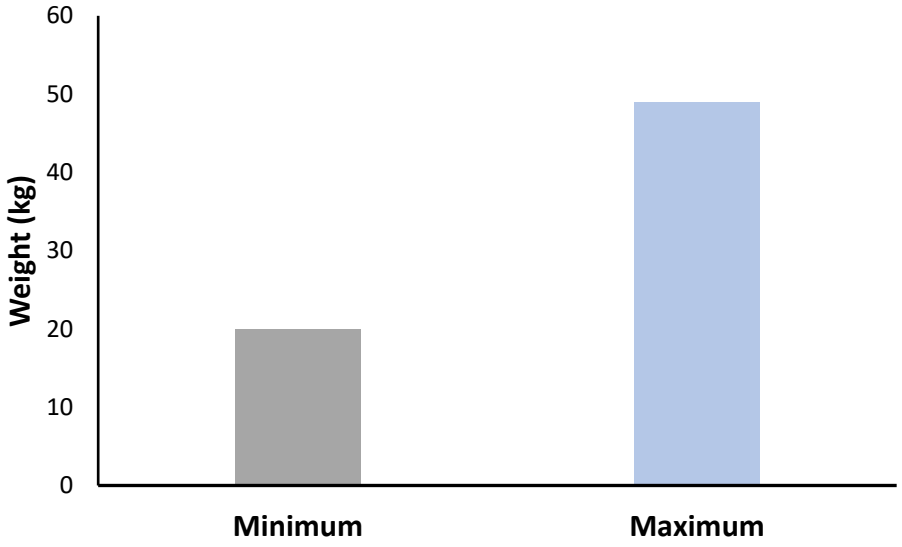

Figure 5. The maximum weight recorded amongst the patient medical records was 49.0 kg and the minimum weight was 20.0 kg.

Age Distribution

The data in **Figure 6** displays the age ranges between the patients who had undergone both TPLOs and fracture repairs. The oldest canine included within the patient distribution was 8-years-old and the youngest was 1-year-old. Therefore, the difference in ages was 7 years.

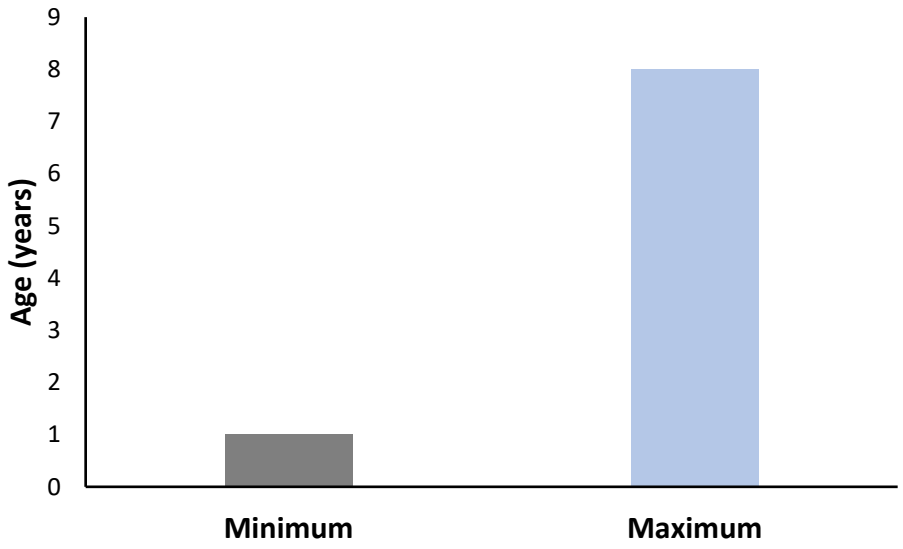

Figure 6. The maximum age included in the patient distribution was 8-years-old and the minimum was 1-year-old.

Clinical Signs of Dehiscence (Figures/ Tables)

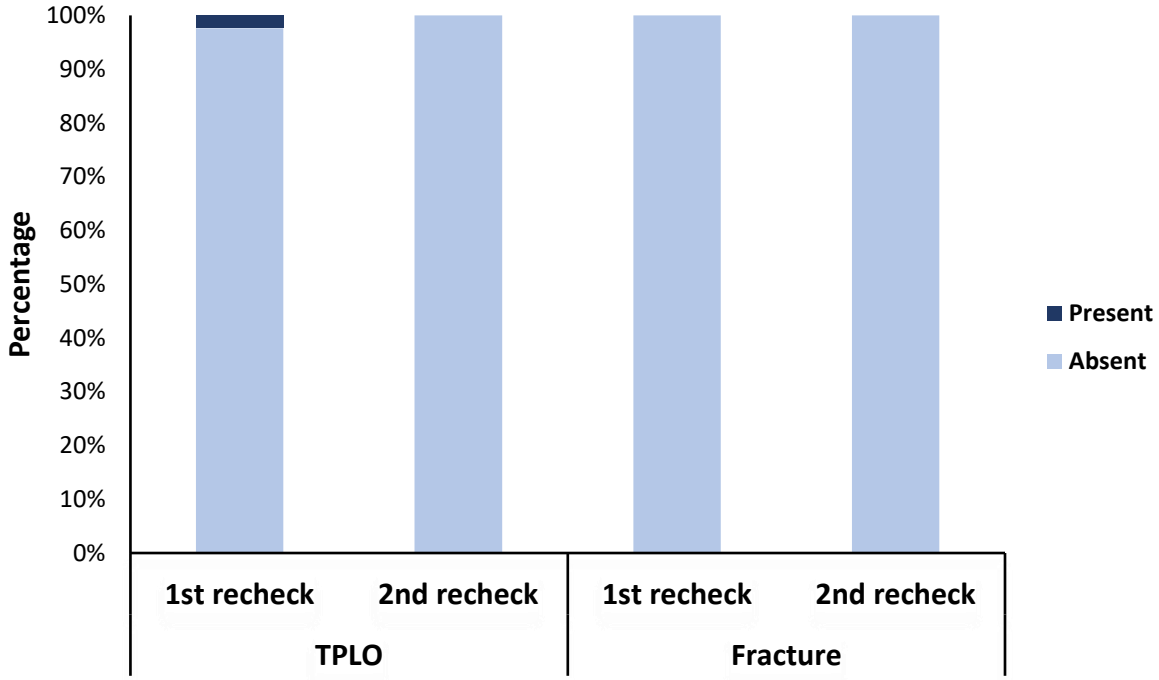

Figure 7. Displays the percentage of patients with and without signs of dehiscence during the first and second clinical examination in postoperative TPLO patients versus postoperative fracture patients.

Table 1. Displays the differences in p-values of the treatment groups for the TPLO and fracture repairs in relation to the presence or absence of dehiscence at the first and second recheck appointments.

Treatment Group	-Treatment Group	p-Value
TPLO / Fracture repairs	Dehiscence at first recheck	0.0460
TPLO / Fracture repairs	Dehiscence at second recheck	0.00320

Clinical Signs of Fever (Figures/ Tables)

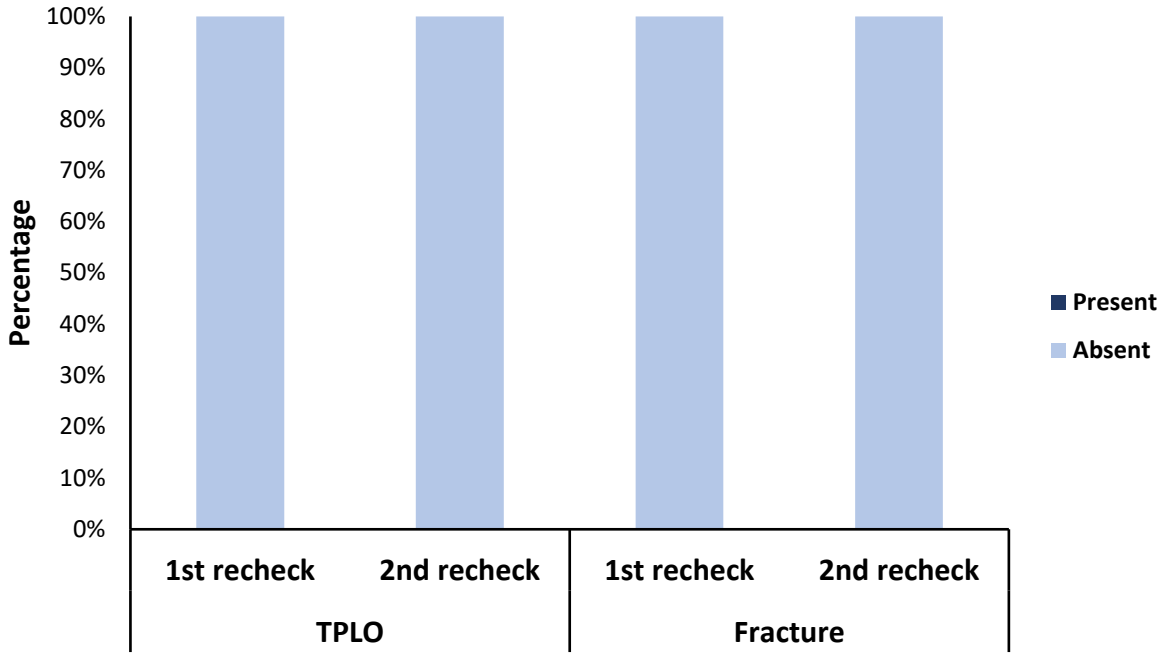

Figure 8. Displays the percentage of patients with and without fever during the first and second follow up appointments postoperative TPLO versus fracture repair. There were no clinical signs of a fever recorded amongst any of the follow-up appointments.

Clinical Signs of Abnormal Localized Swelling (Figures/ Tables)

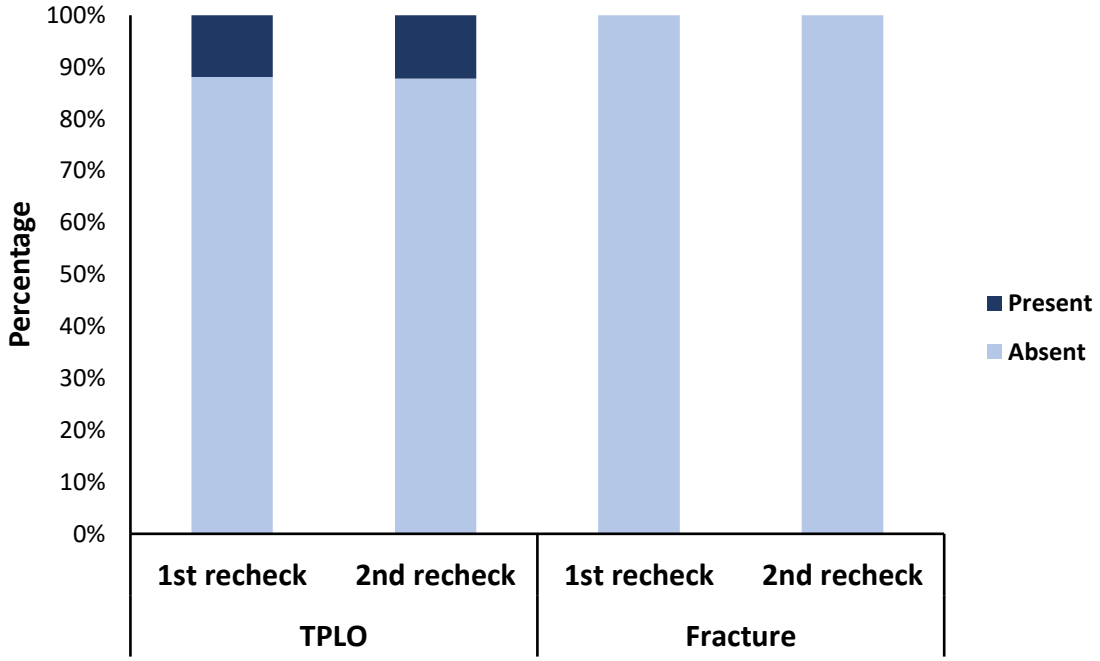

Figure 9. Displays the percentage of patients with and without abnormal localized swelling during the first and second follow up appointments postoperative TPLO versus fracture repair.

Table 2. Displays the differences in p-values of the treatment groups for the TPLO and fracture repairs in relation to the presence or absence of abnormal localized swelling at the first and second recheck appointments.

Treatment Group	-Treatment Group	p-Value
TPLO / Fracture repairs	Abnormal Localized Swelling at first recheck	0.1887
TPLO / Fracture repairs	Abnormal Localized Swelling second recheck	0.3984

Clinical Signs of Surgical Site Drainage (Figures/ Tables)

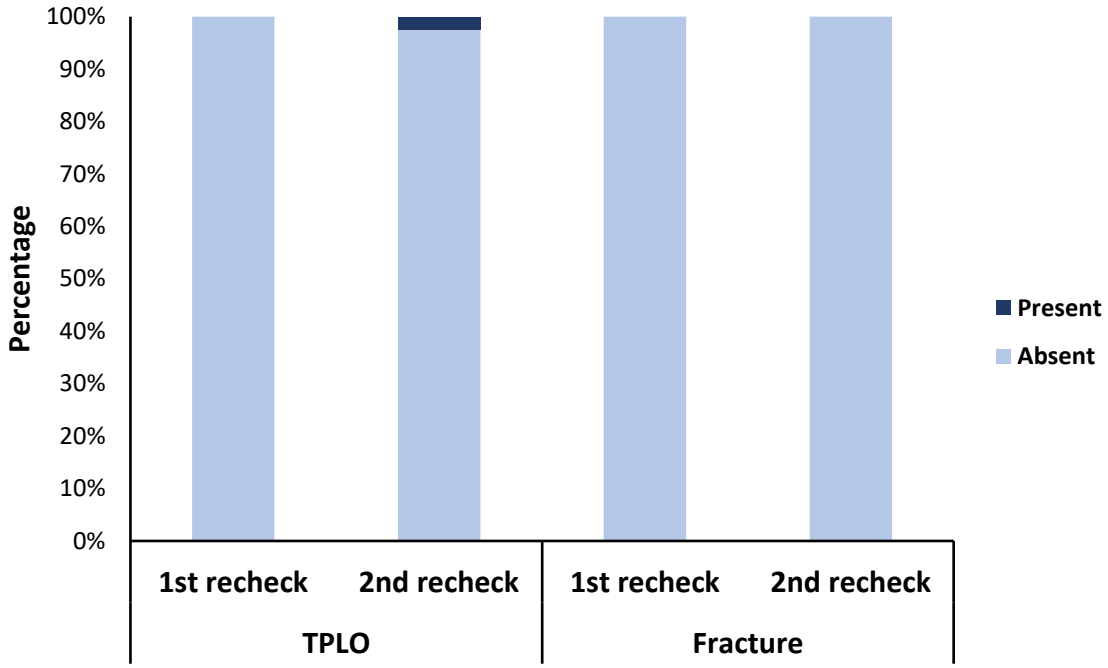

Figure 10. Displays the percentage of patients with and without surgical site drainage during the first and second follow up appointments postoperative TPLO versus fracture repair.

Table 3. Displays the differences in p-values of the treatment groups for the TPLO and fracture repairs in relation to the presence or absence of surgical site drainage at the first and second recheck appointments.

Treatment Group	-Treatment Group	p-Value
TPLO / Fracture repairs	Surgical Site Drainage at first recheck	0.003192
TPLO / Fracture repairs	Surgical Site at second recheck	0.01547

Mean Anesthesia Duration (Figures/ Tables)

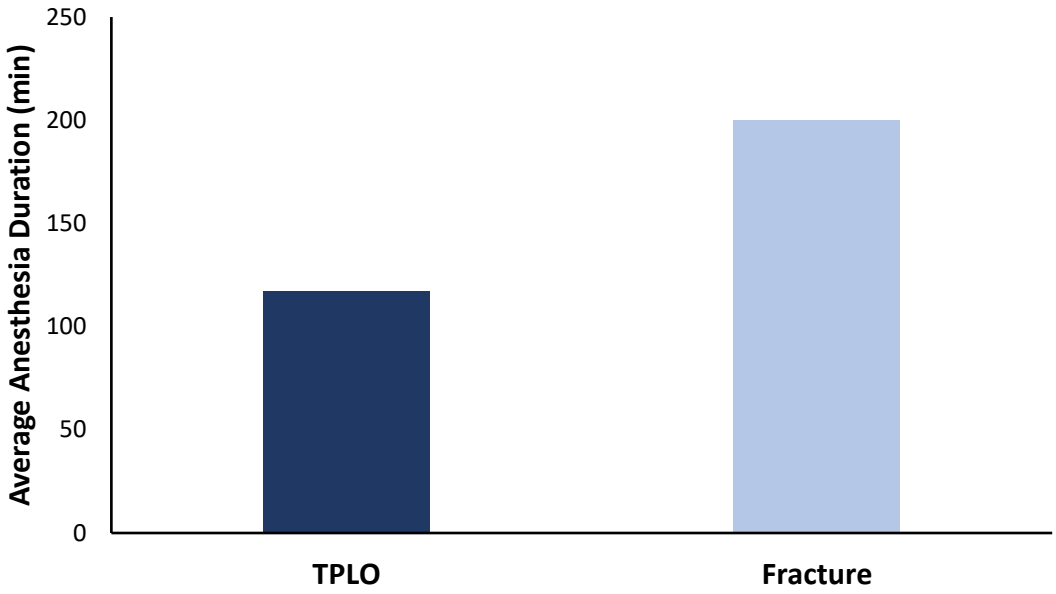

Figure 11. Displays the average duration of anesthesia per minute in TPLO procedures versus fracture repair procedures.

Table 4. Displays the p-value of the TPLO and fracture repair treatment groups and the total anesthesia duration.

Treatment Group	-Treatment Group	p-Value
TPLO / Fracture repairs	Anesthesia Duration	2.732

Abnormal Localized Swelling on Radiographs (Figures/ Tables)

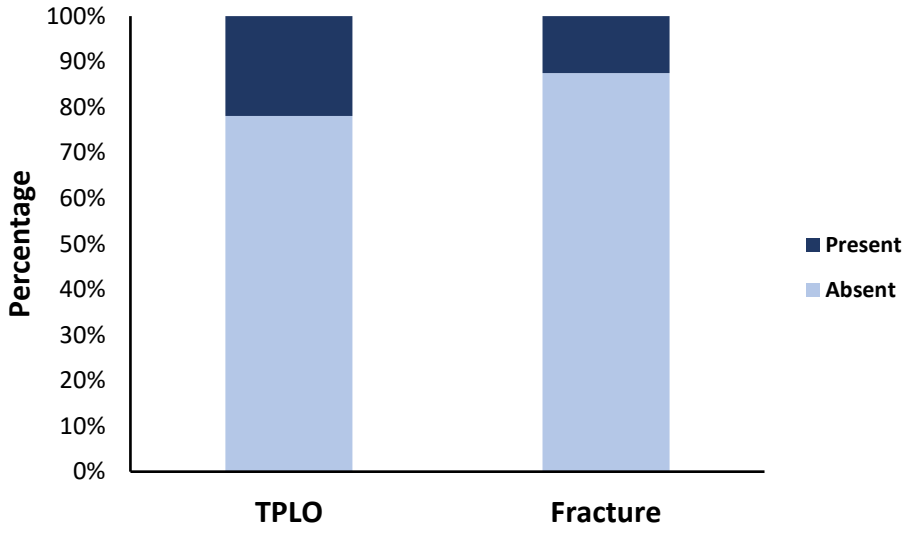

Figure 12. Displays the differences in the percentages of present versus absent localized swelling on second recheck radiographs postoperative TPLOs and fracture repairs.

Table 5. Displays the differences in p-values of the treatment groups for the TPLO and fracture repairs in relation to the presence or absence of localized swelling from second recheck appointment radiographs.

Treatment Group	-Treatment Group	p-Value
TPLO / Fracture repairs	Localized Swelling on radiographs at 2st recheck	0.5743

Abnormal Periosteal Reaction on Radiographs (Figures/ Tables)

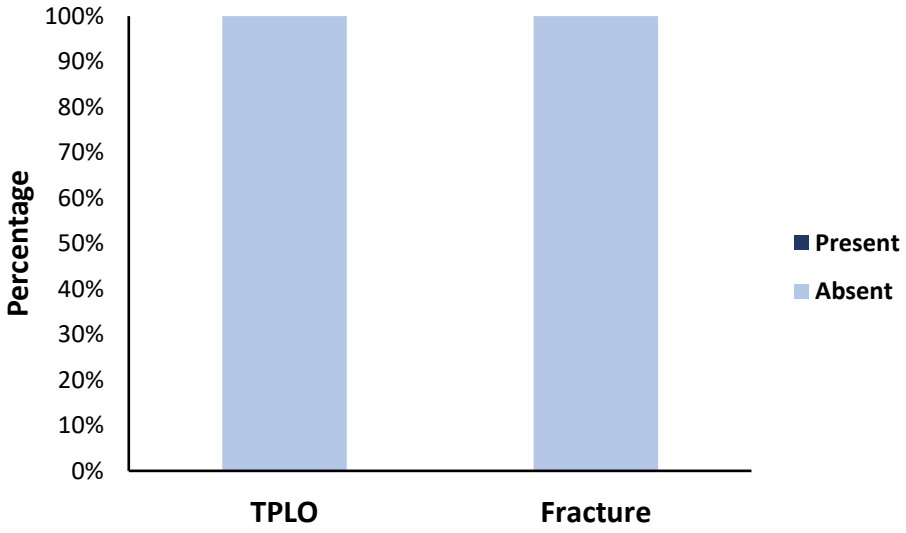

Figure 13. Displays the differences in the percentages of present versus absent abnormal periosteal reaction on second recheck radiographs postoperative TPLOs and fracture repairs. No cases were reported as present periosteal reaction in either type of procedure.

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